Title: Method and Apparatus For CDMA pn Scanning at Indoor and Other Obstructed Locations.

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Relationship to Other Inventions:

1. This application claims priority from Serial No. 60/226,287, filed August 21, 2000, and entitled "Method and Apparatus for CDMA PN Scanning at Indoor and Other Obstructed Locations."

Field of Invention:

2. The present invention relates to radio communication systems inclusing CDMA cellular and PCS telephone networks, and in particular, to a method and apparatus for pn scanning at indoor and other obstructed locations.

Background of the Invention:

3. CDMA cellular and PCS telephone networks are a type of mobile communication network that use psuedo-noise digital codes ("pn-codes"). Pn-codes spread the transmitting signals' spectrum so that multiple communications can occur over the same channel. This is achieved by multiplexing and demultiplexing a particular communication signal within the common channel. This process allows many communications to occur simultaneously. A plurality of base stations use the same pn-codes with each base station assigned a different initial phase of code sequences.

4. The synchronization of multiple base stations is achieved by the use of the Global Positioning System (GPS) receivers at each base station location. Aided by appropriate stable clock generators, these receivers supply accurate timing information to the base station. Thus, it is important to measure the phase offset of each base station during initial installation and routine

maintenance in order to ensure the integrity of the network. Testing devices, for example, pn-scanning receivers, used for this purpose must have a means to synchronize their timing to the absolute time used. An accurate, universally available timing information source, for example the GPS, is required.

5. These testing devices also assess the adequacy of signal coverage within a service area for cellular and PCS network as well as measure the quality of the CDMA signals from a base station. One measurement device is the pilot scan. The pilot test scanner requires access to an external, accurate clock. The Global Positioning System, GPS, is used as the clock source in the typical pn scan device. As such, these test devices have GPS receivers.

6. One of the methods used for the synchronization of the test receivers for CDMA pn-scanning requires a GPS receiver as part of the test instrument. Wherever the GPS signals are available, that is in most outdoor settings, this method provides an accurate and convenient way of synchronization. However, it is not practical for settings where there is no reliable GPS coverage, such as indoor settings, some urban locations and wherever access to GPS is obstructed.

7. Another possible approach relies on the information contained in the CDMA signal itself to derive the accurate frequency and timing information. Berkeley Varitronics Systems sells The Hummingbird™ a handheld PN scanner suited for indoor microcell IS-95 analysis. The Hummingbird demodulates the synchronization channel and reports base station ID, time and date all without use of the GPS. However, this approach suffers from an inherent flaw, since it relies on the accuracy of the base station's signal for the testing of the same signal. Additional

problems associated with this approach are the uncertainty caused by an unknown propagation delay from the base station and the complexity of the implementation.

8. Patent No. 6,101,176 was issued to Honkasalo et al. for a "Method and apparatus for Operating an Indoor CDMA Telecommunication system" addresses the issue of indoor and outdoor CDMA competing with each other. Honkasalo proposes that the indoor system monitor the outdoor system to identify those radio resources not in use or interference free so that the indoor system can utilize those resources.

9. Patent No. 6,058,136 was issued to Ganesh et al. for a "System and method for PN offset index planning in a digital CDMA cellular network." This invention describes a system and method for establishing PN offsets so as to minimize interference. One of the parameters chosen is designed to optimize the pn scan rate.

10. Patent No. 5,945,948 issued to Buford et al. for "Method and apparatus for location finding in a communication system" is concerned about being able to locate a subscriber by measuring the user's cell phone transmission signal's angle of arrival and time arrival at one or more CDMA base stations. From this information the user's location can be approximated. Since a more accurate determination can be made with multiple measurements of the subscriber's transmission signal, one embodiment of this patent is to augment base stations with PN scanners so as to increase the coverage for purposes of locating subscribers. These scanners would be equipped with GPS receivers so as to synchronize the scanners' clocks. Part of the analysis requires calculating the time it took the signal to traverse from transmitter to receiver.

11. Patent No. 5,398,276 was issued to Lemke et al. for "Cellular-system signal-strength analyzer". Lemke was concerned about measuring signal strength of radio frequency cellular

telephone transmissions in locations frequented by pedestrians including indoors locations and charting the signal strength at different geographical positions. Geographic positioning is calculated using a laser range finder along with a portable computer. Standard AMPS scanner, carried in a backpack is used to measure RF signal strength. AMPS (Advanced Mobile Phone Service) is concerned with analog, frequency division multiple access cellular systems and as such would not be concerned with time synchronization.

12. Patent No. 5,590,177 issued to Vilmur et al. for "Method for preventing a dropped call during a handoff in a radiotelephone system" addresses the problem of dropped calls when one base station hands off a cellular call to a new CDMA base station. The new CDMA base station signal strength to power ratio is measured at the receiver location. As the ratio diminishes to some threshold level, a signal would be sent to the original CDMA cell location indicating that an alternate base station is required to maintain the call. A PN scanner is used to measure the signal to power ratio at the receive location.

13. Testing CDMA signal propagation and coverage using a PN scanner is well known. However, when the test location does not have ready access to a stable, accurate timing synchronization source, the test results may be suspect.

14. What is required is a method and apparatus to provide a simple method and apparatus for testing CDMA signal propagation and coverage, including pn offset measurements, in indoor and similar settings with no or limited access to GPS signals.

Summary of the invention:

15. It is the objective of the present invention to provide a simple method and apparatus for testing CDMA signal propagation and coverage in indoor and similar settings with no or limited access to a global time synchronization signal such as provided by the GPS.

16. It is a further object of the present invention to provide a CDMA signal tester devoid of a GPS receiver.

17. It is yet a further objective of the present invention to provide a simple method and apparatus for testing CDMA signal propagation and coverage in indoor and similar settings with no or limited access to a global time synchronization signal such as the GPS.

18. The present invention is designed to test base stations' signal adequacy by using two devices, a test scanner and a reference transmitter. The test scanner scans pilot channel signals from base stations and from the reference transmitter. The reference transmitter, a low powered CDMA transmitter that transmits pilot channel signals, is also equipped with an internal clock and a GPS receiver for purposes of setting its internal clock. The reference transmitter uses a uniquely marked pilot signal, that is, the pn sequence information contained in the pilot channel signal is readily identifiable. The reference transmitter pilot signal will also include time of transmission. An embodiment of the present invention uses multiple pilot channel transmissions from the reference transmitter. This reinforces the ability to identify the reference transmitter's pilot signals.

19. The reference transmitter is positioned to have access to a GPS signal and to be close to the test scanner so that the time delay between transmission and reception by the test scanner is imperceptible. This is achieved, according to one embodiment, by placing the reference transmitter within 240 meters of the test scanner. This distance represents one chip in

corresponding pn offset units. Here, a chip is a cycle per second. The CDMA spread spectrum frequency is approximately 1.25 M cycles per second. Radio waves travel at approximately $3x10^8$ meters per second. Therefore, a signal transmission will travel about 240 meters in 1/1.25M seconds.

20. The test scanner comprises a pn pilot scanner additionally equipped with an internal clock. When a pilot signal is received, the test scanner is able to distinguish between a base station pilot and the reference transmitter pilot by the pn sequence information. A pn sequence that is uniquely marked, that is, it does not resemble pseudorandom noise, is known to be from the reference transmitter. Since the reference transmitter is close by, its time of transmission is very close to the GPS time. The test scanner can set its internal clock with this information. The test scanner is then be able to test each base station's pilot channel adequacy without direct access to a GPS signal.

21. Another embodiment of the present invention has no GPS receiver built in the test scanner and, therefore, avoids the cost of the GPS receiver (most pn scanners have a GPS receiver).

22. Yet another embodiment of the present invention uses a delay-lock loop system to track pattern shift of the reference transmitter's pilot signals. The delay-lock loop allows the test scanner to accurately adjust its internal clock as the reference transmitter pilot signals underwent a phase shift. The delay-lock loop is formed by: a voltage controlled clock oscillator; a digital to analog converter; and a processor.

Brief Description of the Drawings

23. **Figure 1** illustrates the overall architecture according to one embodiment of the present invention

24. **Figure 2** illustrates the data flow of the present invention

Detailed Description of the Invention:

25. According to the invention, the system for such testing consists of two units. One of the units ("scanner") is essentially a pn scanner with an internal timing circuit. It is used in the testing area for pn scanning where access to a global time reference such as the GPS is limited or not available

26. The other unit is placed conveniently proximate the measurement area, in most cases close to a door or window, or wherever there is an unobstructed reception of GPS signals. This unit ("reference transmitter") contains a GPS clock that provides an accurate clock and timing, and a reference pilot transmitter. The latter is a low-power transmitter of an accurate, GPS-synchronized CDMA pilot or pilots with selectable pn offsets. The preferred embodiment is to use an offset close to zero, e.g., close to zero chips.

27. Referring to **Figure 1**, the overall architecture according to one embodiment of the present invention is illustrated. The present invention generally comprises a local CDMA transmitter (LCT) **30**, a test scanner **40**, and at least one CDMA base station **20**. The LCT **30** and CDMA Base Station **20** are in communication with a global positioning system **10**.However, the test scanner **40** may be in a location where signals from the GPS **10** are obscured by some form of barrier **14**.

28. The Global Positioning System **10** provides a universal clock to the system. Time information **12** is universally available to any device with a GPS receiver **23**. However, the Test

Scanner **40** is in a location where the GPS time broadcast **12** is obscured by a barrier **14**. A local CDMA transmitter **30**, also known as the reference transmitter, is positioned close to the Test Scanner **40**, has non-obscured access to GPS **10**. LCT **30** is equipped with a GPS receiver **23**, an internal GPS clock **22** and a processor **32** that sets the clock. A pilot signal **34** with a unique pn sequence pattern **35** is transmitted in a CDMA pilot channel. Time data **36** is included in the pilot signal **34** transmissions.

29. Test scanner **40** performs pn scans for the pilot signals **42**. If the processor **46** recognizes the pilot signal as coming from the LCT **30**, the test scanner processor **46** sets the test scanner's internal clock **44**. If the test scan detects a pilot signal that is not uniquely patterned, the test scanner processor **46** measures the CDMA Base Station **20** pilot signal **24** for propagation and adequacy of signal coverage. Usually, multiple CDMA base stations are measured.

30. A CDMA base station **20** has a GPS receiver **23** and GPS synchronized clock **22**. The base station pilot signal **24** is characterized by having a random like pn sequence **25** which is easily distinguishable from the uniquely patterned **35**, non-random pn sequence used by the LCT **30** (or reference transmitter). The pn offset **26** is time based, thus allowing a CDMA base station receiver, such as the test scanner **40**, to correctly interpret the pn code. Use of an accurate, global time synchronization source is absolutely critical in this analysis.

31. A clock adjuster **48** is also available in one embodiment of the present invention. It is based on monitoring successive scans of the reference transmitter (LCT) for drift in the pn sequence pattern. Time adjustment is implemented with a delay-lock loop method as described below.

32. Referring to **Figure 2**, the data flow of the present invention is illustrated. The LCT (reference transmitter) **100** receives GPS time signals, which allows the LCT to set its internal clock **102**. The LCT has a unique, non-random pn sequence in the pilot signal, thus the pilot is marked with a special pattern **104**. The uniquely marked pilot is broadcast and time information is included **106**.

33. The test scanner scans the pilot channel of CDMA transmissions **108**. Because the LCT has a uniquely marked pilot signal, the test scanner readily identifies LCT scans **110**. Using the time information from LCT, the test scanner sets its internal clock **112**. The test scanner also scans pilot signals from at least one base station **114**. The random nature of the pilot's pn sequence pattern allows the test scanner processor to conclude that the scan is not from the LCT **116**. The test scanner measures and evaluates the signal from the base station for propagation and coverage adequacy **118**.

34. In a preferred embodiment, the reference transmitter emits an easily recognized pattern ("marker") consisting of several closely positioned pilots. The test scanner recognizes the marker as emanating from the reference transmitter. Since the reference transmitter will have best performance if positioned at a distance of no more than one chip in corresponding pn offset units (about 240 meters), the propagation delay error will be negligible in most instances. Given the known position of the reference pilots, the whole scan measured and calculated by the scanner in the traditional way can be positioned correctly by the processing program in terms of offsets in reference to absolute time. The scan traces positioned by the described method will display the reference pilot group in the beginning (if it corresponds to zero offset), as well as other pilots corresponding to existing CDMA base stations. Scan traces for multipath and delayed

components will also be positioned by the present invention. The test scanner uses the time information received from marker unit to set its internal clock so as to accurately calculate pilot time and pn offset.

35. In addition to positioning each measured scan, there is a processing program that measures the relative displacement of the reference pilot pattern from scan to scan. That is time drift is detected and compensation made. The program adjusts a timing generator, which is part of the scanner, in order to nullify the drift in the pattern position. Thus, the processing program is part of a delay-lock loop formed by a voltage-controlled clock oscillator, digital-to-analog converter, included in the test scanner.

36. Another benefit of the disclosed invention is that the scanning apparatus does not require a separate receiver channel for the reception of timing information, as would be the case if timing information were received from an outside location using a radio signal other than a CDMA pilot.

37. A method and apparatus For CDMA pn Scanning at Indoor and Other Obstructed Locations has now been illustrated. It will be appreciated by those skilled in the art that other variations of the present invention are possible without departing from the scope of the invention as disclosed.